Detecting Extrasolar Planets

In this activity, students learn about the search for extrasolar planets using the method of transit detection. Teams construct models that demonstrate transits.

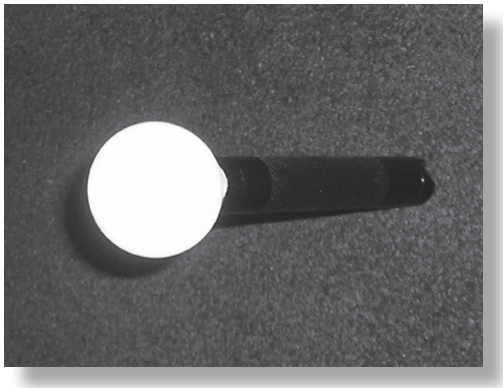
Materials

For the class

Download Earth-based image of Venus transit by Becky Lowder (to the right).

For each team of 4-6 students—materials to make a model transit

- 1 "model star" light-source, preferably a non-LED reading light or flashlight that can have a ping-pong ball (with a hole made in it) mounted over the light (see photo below). Alternatively, a plug-in lamp with frosted bulb, no lamp shade (e.g. portable goosenek lamp, swing-arm lamp, or clamp-on lamp), and extension cords as needed.
- Several round, opaque beads - 5 mm to 15 mm in diameter
- 2–5 pipe cleaners - 30 cm (1 ft) long
- 1–2 chopsticks or thin dowels
- Black thread - about 1 m
- Index cards
- Tape
- Modeling clay
- Bag to hold the above materials
- Safety glasses for all students



Small flashlight with ping pong ball cover

A. The Hunt for Extrasolar Planets

1. ***Get Set:*** Ask "Do you think there may be planets orbiting other stars—extrasolar planets or exoplanets?" Some students may know of the astronomical search for extrasolar planets.
2. ***Questions about extrasolar planets.*** Have students generate a list of questions about newly discovered extrasolar planets. Examples:
   - How large is the planet ?
   - How far is the planet from its star?
   - How long does the planet take to orbit its star?
   - Is it in a planetary system with other planets?
   - Could you have a habitable planet without a star?
   - Is the planet Earth-like?
   - Could the planet have life on it?
   - Can we detect the new planets?
3. ***Why extrasolar planets are difficult to detect.*** Ask "Why is it difficult for astronomers to find extrasolar planets?" If the following points are not mentioned, be sure to discuss:
   - Other stars are very, very far away from us.
   - Unlike stars, planets don't generate their own light. Instead, they reflect the light coming to them from stars, and shine very dimly.
   - Even viewed through a telescope, the light from a planet is overwhelmed by the light from the star that it orbits.

Photo by Becky Lowder: http//www.transitofvenus.

B. Introducing Transits

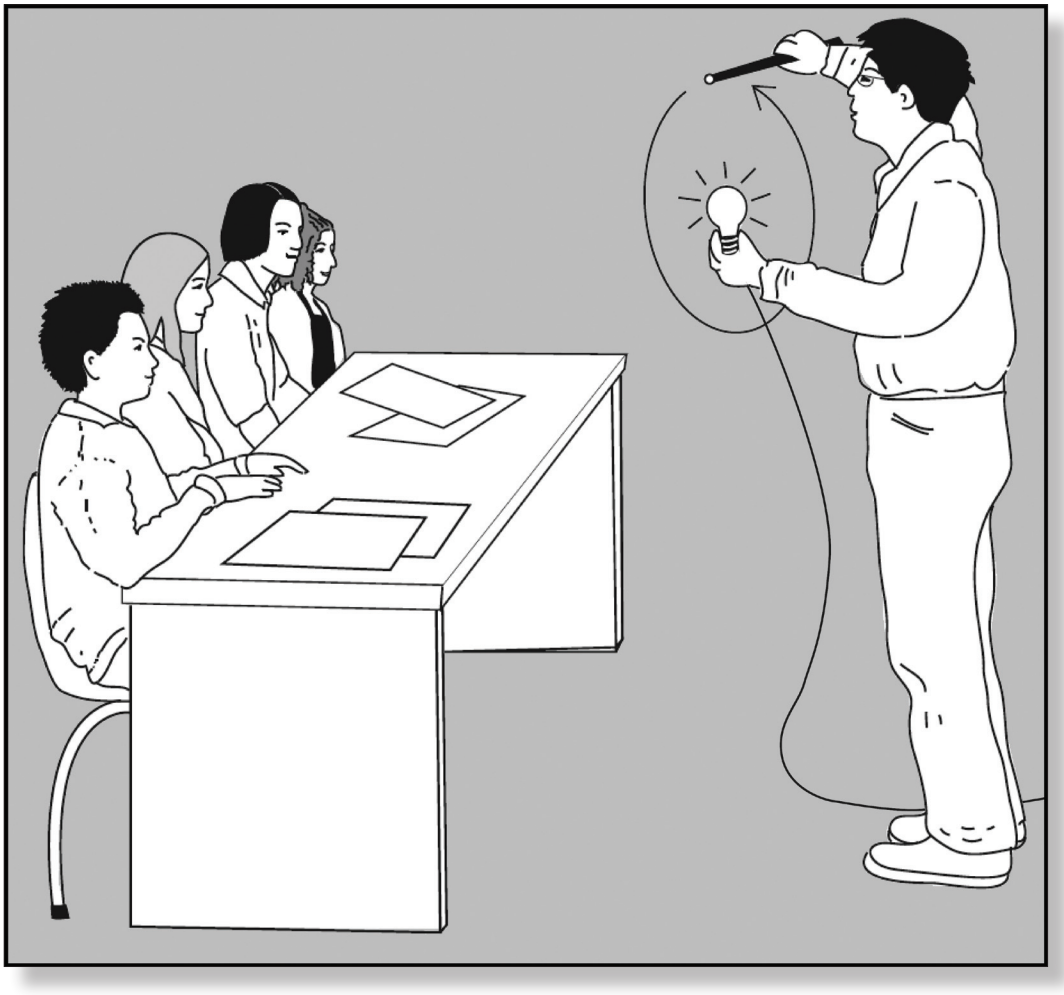
1. ***Transit of Venus.*** Show the image of the Sun with Venus in transit. Ask students to describe what they see. Confirm that the image is of our star, the Sun with the planet Venus passing in front of the Sun. Define a transit: when one object passes in front of another object.
2. ***Extrasolar planet transits.*** Ask "What will observers see if they watch a planet transit a star much more distant than the Sun?" Have them discuss the question in pairs, and then share their ideas. Explain that since other stars are so far away, it is very difficult for observers to see the disks of other stars, much less dark spots on the stars during transits. Instead, we see the star dim slightly for several hours as the planet passes in front of it.

C. Making Transit Models

1. ***Challenge teams to make Transit Models.*** Organize the students in teams of 4 to 6 to construct models that demonstrate transits. Show them the materials available. The lamps/flashlights represent stars and beads or other materials represent planets. Explain that they will demonstrate their models to the rest of the class. Safety: If using 110V lamps, caution students: be careful about tripping over the power cords; do not touch a light bulb that has been on until it has cooled. Light bulbs get very hot quickly; nothing should be taped to the light bulb. Wear saftey glasses to protect against broken light bulbs.
2. ***Construct Models.*** Give the teams 10-15 minutes to construct models. Circulate to check progress and safety. Encourage students to consider input from all team members in creating models. After 10-15 minutes, let teams know that

they should finish their models and plan their demonstration. Then have them all switch off the lamps.

3. ***Demonstrate the Models.*** Each team demonstrates and explains their model. Allow other students to critique the strengths and weaknesses of each model.
4. ***Glare.*** Students may notice that the glare from the light bulb makes it difficult to observe the models. If not, point this out and explain that the glare of the real stars is a major reason it so difficult to observe the extrasolar planets.
5. ***How Often Can We See Transits?*** Darken the classroom, and switch on a lamp representing a star. Show students a bead attached to the end of a stick and tell them it represents a planet. Move the planet slowly around the star in a vertical orbit and have students raise their hands if they can see the planet pass in front of the star. Only a few students—those who are seated in "line of sight" with the plane of the planet's orbit—will raise their hands. Ask "What kind of orbit would allow almost everyone in the class to see a transit?" Under student direction, demonstrate the orbit, a horizontal one, with the planet passing between the star and the students. Even with this orbit, though, some students may not see the planet pass directly in front of the bulb. This illustrates that the likelihood of seeing a transit is low.



6. ***Scale of the models.*** Ask students to imagine that their models represent a extrasolar planet with an orbit about the diameter of Earth's orbit. (That's 150,000,000 km, or about 8 light minutes.) Remind students that the nearest stars in our galaxy are several light years away, which is roughly a million times the orbit of the planet. In this scale model, then, the observer would be hundreds of kilometers away from the light bulb compared to the size of the extrasolar planet's orbit.

D. The NASA *Kepler Mission*

Explain that the NASA *Kepler Mission* (launched in 2009) monitors more than 100,000 stars simultaneously, measuring changes in their brightness, and looking for sequences of transits. But because only a small fraction—less than 1%— of planets and stars will be lined up just right to detect transits, each planet found by this method represents about a hundred more extrasolar planets not found!

1. ***Student Questions:*** Discuss whether transit observations could provide answer any of the questions generated earlier.
   - ***How large is the planet?*** [The size of the planet determines the change in brightness of the star during a transit]
   - ***How long does it take for the planet to orbit its star?*** [Measuring the time between transits tells us how long it takes the planet to orbit its star.]
   - ***How far is it from its star?*** [We can use Kepler's 3rd law to calculate the distance from the star to the planet. This assumes that the parent star is the same mass as the Sun.]
   - ***What is it's temperature?*** [With information about the type of parent star, and the distance from the star to the planet, we can calculate the temperature of the planet.]
   - ***Is it in a planetary system with other planets?*** [If more than one planet is making transits, they may be different size planets, and definitely have different orbital periods, just as in our solar system. The timing of transits and the changes of brightness during the observed transits provides this kind of information.]
   - ***Is the planet Earth-like?*** [By finding out how large the planet is, astronomers hope to find out whether planets the size of Earth are common, and how many of them are about the same distance from their stars as Earth is from the Sun.]
   - ***Could the planet have liquid water?*** [Liquid water could exist on the surface of an extrasolar planet if its distance from the star and the star's temperature are both just right.]

Download "Detecting Extrasolar Planets" and other activities at **http://kepler.nasa.gov/ed/activities.html**